

## Making the Film

### How Stanley and Stella came together

At the SIGGRAPH '86 film show, Russell Noftsker, Chairman of the Board for Symbolics, Inc., leaned over to Tom McMahon, director of R&D at Symbolics Graphics Division (SGD), and said "Maybe we should do a film." He was thinking, as were many others in management, that Symbolics needed a higher profile in the animation community. A film would be a good way to show that the Symbolics animation and paint system was capable of challenging and attractive animation. A successful film would be a valuable marketing tool.

Tom McMahon, who would be the film's executive producer, agreed the film would be good for the company's image. He also knew that some of the software developers on his staff had been itching to do production work. Many had worked on feature films before coming to SGD, but production at SGD had been limited to occasional commercials, notably for HBO and Playboy Television. The film would also be beneficial since production work would give the developers more of a feel for their customers' concerns and would undoubtedly suggest new features for the animation system.

For the SGD developers, the film was an opportunity to try out some of the experimental programs and see how far the system could be pushed. The developers, who best knew the system, would have several months to find out what it could and could not do.

With everybody agreed, an initial commitment was made to produce a 20-second spot that featured the boids behavioral animation software written by Craig Reynolds. It was Gary Demos's idea to feature the experimental flocking motions since the interest generated by the software would ensure the film's acceptance by the SIGGRAPH film jury. Demos was involved because Whitney/Demos Productions (WDP) would help produce the film. Working on a film with Symbolics would be a good way for WDP to learn as much as possible about the Symbolics system before taking in paying jobs.

### Getting off the ground

The 20-second flocking motion spot envisioned in the beginning didn't stay simple for long. With WDP's Philippe Bergeron available, the film was expanded to include character animation. Along with characters comes a story so Robert Fusfield was asked to design a storyboard that combined character animation and flocking motion. His concept hinted at a love story between Stanley the bird and Stella the fish. The actual events of this love story evolved over time, but Fusfield's original concept of a globe and separate worlds stayed till the end.

The schedule drawn up in January by producer Michael Wahrman called for rough animation and audio to be complete by the time of the jury version (the version sent to the SIGGRAPH jury for acceptance to the film show). The weeks immediately before the final deadline would be used for rendering, re-rendering, and fine-tuning. This schedule turned out to be optimistic. The animation was far from complete. Jim Ryan constructed

the jury version from almost everything that had been done to illustrate the story -- black-and-white storyboard frames, color storyboard frames, black-and-white S-Dynamics motion tests, S-Geometry shaded scenes, rendered frames. But enough animation (30%) had been completed that everybody was confident the film could be finished on time. All would have been fine, except that nobody liked the jury version.

The cartoonish jury version made it clear that the static storyboard did not translate well into animated motion. The storyboard was not well designed for the high number of scene-to-scene cuts it contained, making the story difficult to follow even for those who knew the story. Philippe Bergeron, who did the character animation for the film and was part of the film jury, found himself having to explain the film to his fellow jurors. A more serious problem was the strong reaction of SGD's Marketing department, who, among others, objected to the ambiguous tones the film had acquired.

However, there was nothing wrong with the individual scenes. The quick scene-to-scene cuts were bad and the story problematic, but these were solvable problems. And the animators were starting to understand better what they wanted in a film. As it was, Tom McMahon and his staff wanted the film project to continue.

About this time, Michael Wahrman asked Larry Malone to take a more active role in directing the film. Michael also got his brother Wayne, a professional film editor, to critically review the piece. Wayne's suggestions amounted to redoing the storyboard, and this Larry and Michael agreed to do. The number of cuts was reduced and replaced with sweeping camera moves that slowly revealed the scene and allowed the viewer more of a feeling of the globe and its separate worlds. The length of the film was doubled since part of the jury version's incomprehensibility was the high speed at which the action unraveled. Simplifying the story also placed emphasis back on the flocking motion. The ending of the film was still in the air.

Redoing the storyboard meant throwing away all previously completed frames. Instead of a few short weeks to finish a 68-second film for which 30% of the animation was finished, the animators would have a few short weeks to finish a two-minute film for which only the models were complete. The demands of the longer animation allowed no time for fine-tuning or rendering scenes twice.

But the new schedule did force the animators to get down to business. Larry Malone, who would be the first to work on the script, would animate the camera. Since Larry was also the developer of S-Geometry, he could best exploit the possibilities of animating the camera. The script would then pass to Philippe Bergeron, who would animate the characters before passing the script to Craig Reynolds, who would animate his flocks. Certain shots required an additional step of placing panels and cylinders in the scene.

This handing off of the script from one animator to another was not always so clean. Very often, two or more would be working simultaneously on the same object. The design of the system made this easy but left open the possibility that two versions of the same object might be saved out, one version not having the changes made to the other.

This danger of "version skew" made it important that the animators communicate and motivated Larry Malone to add a post-film safeguard to decrease the chances.

New music was produced by Richard "Doc" Bailey to accompany the film. Doc's music was a complete change from the jungleland sounds and honking that had accompanied the jury version. Doc's music was majestic and, when combined with Larry's camera motions, entirely changed the tone of the film and gave many of the animators a renewed sense of purpose.

### Modeling and creation of objects

The models for Stanley and Stella were about the only things salvaged from the jury version. The models had been constructed by the versatile Doc Bailey, who had had no previous experience on the Symbolics system. He created most of the subobjects that make up Stanley and Stella with the spline surface feature of S-Geometry. The spline surface starts out as a mesh of wires with control points that are manipulated to create a shape. When the desired shape is achieved, a polygonal approximation of a spline based surface is then generated from the control points.

The fishes and birds of the flock and school are actually low-resolution versions of Stanley and Stella (here resolution refers to the number of polygons). The low-resolution versions were created by passing the models of Stanley and Stella through the derezzer, a program written by Michael Wahrman that reduces detail by sorting and dissolving edges according to the hardness of the edge. (The hardness of edges is determined by the size of the angle of two faces, though edges between faces possessing different attributes are preserved.) Whereas the high-resolution Stanley is made up of approximately 11,000 polygons, low-resolution Stanleys contain about 1,000. (The derezzer will be available to customers as part of the 7.2 S-Geometry hacks. lisp file.)

The ice barrier that divides the globe required special attention because it had to be solid, yet breakable; detailed for close-up shots, yet general enough for long-distance shots; static yet dynamic. These difficulties were solved by Kevin Hunter who added new mapping features to S-Render. Variable resolution bump maps were added so that the bump-opacity map for the barrier had a 256 x 256 version for distant shots and a 512 x 512 version for close ups. The continuous, sparkling effect as the barrier breaks was achieved with the use of dynamic bump maps. Kevin computed a 3D matrix of data consisting of fractal noise using a prototype of the array processor then under development at SGD.

Successive planar "slices" of this cube of data were used as frame-by-frame bump and opacity maps for the ice blocks. Because each slice varies only slightly from the slices on either side of it, a shimmering effect is produced by the smoothly changing maps as they interact with the Phong highlights. Through most of the animation, the ice barrier that divides the fish and bird worlds is a single object. For the shot in which Stanley breaks through the barrier, a compound object of 33 subobjects was substituted for the

single object barrier. The compound barrier was modeled by Andy Kopra to create a jagged hole in the center of the barrier, with "cracks" that define the ice blocks and radiate from the point at which Stanley first contacts the ice. The falling and rotating blocks were controlled by a standard S-Dynamics script that was generated by software written by Andy; the speed and direction of translation and rotation were procedurally determined based on a simple dynamic model of the effect of Stanley's impact. This script was then included by Philippe as a subsequence in the script for the entire shot. A frame action in a separate sequence controlled the animation of the bump and opacity mapping of the ice blocks as they fell.

The background starfield was rendered separately from the foreground scenes because the sphere on which it was mapped was so large that it forced setting a very large yon distance, which coupled with the small hither distance required by the close-up shots. Such a loss of numerical precision would cause the starfield to jitter. (See the article on keying, page 1, for how the background starfield was composited with the foreground scene.)

#### Character animation

Character animation has unique requirements because of the type of fluid motion it involves. Translations and rotations, which are usually sufficient for rigid body transformations, are of limited value in character animation, which requires an object's vertices to move in relation to one another.

Spheres of influence is an S-Geometry facility that was written specifically to make it easier to define non-rigid motions. In using this feature, a vertex is selected and a spherical volume around the vertex is defined. Manipulating the selected vertex influences the vertices within the defined area. For example, as the selected vertex is pulled, the vertices within the defined area are pulled along with the selected vertex as if influenced by it. The effect of the influence is greatest on the vertices closest to the selected vertex and falls off for the vertices toward the outer edge of the sphere. The rate of falloff can also be controlled, making spheres of influence extremely powerful not only for simulating facial expressions but in all situations where there is continuous, elastic movement. The gentle side-to-side motions of Stella's fins were also animated by using this technique.

Spheres of influence were used to manipulate an object by displacing its vertices from an initial state. Another new S-Geometry feature allowed the naming and saving of these displacements so they could be retrieved and animated in S-Dynamics. (See Hints and Hacks for instructions on animating a displacement.)

Philippe Bergeron combined spheres of influence and displacements to create almost all of the character animation. Philippe began with an object in a neutral state and then used spheres of influence to manipulate the object to simulate an emotion such as

"happy" or "sad." He then saved this configuration as a displacement. None of the expressions created by displacements were fixed, however. Any intermediate state of the vertices could be used to create an expression. Nor was the control limited to positions between the original and displaced states of the object; positions on either side of the defining states could also be used. Since multiple displacements were created separately for each object, Philippe could also control the order in which these displacements were animated. In one expression, Stanley might raise his eyebrow before smiling, while in another, Stanley might smile first, raise his eyebrow, and then turn his head.

For the eye movement, Philippe used a technique in which the eyes are focused on some point of interest in space. As the head moves, the eyes shift to remain focused on the point of interest; as the point of interest moves, so do the eyes. The point of interest in the film was a scaling center, which was animated in S-Dynamics. The eyeballs were procedurally rotated by a frame action that "examined" the position of the scaling center frame by frame.

#### Behavioral animation

The centerpiece of the film is Craig Reynolds's boids program. Boids (bird-oid) is an experimental program that simulates flocking motion. Craig's program differs from conventional animation in that the paths of the individual boids are not scripted but are determined by rules of behavior and a system of constraints. The animator gives a general direction, "Go here," but the actual path to "here" is determined by the boid, which must "act" within certain constraints written into the program. A boid, for example, must avoid obstacles in its path. Other constraints are proper behavior for participation in a flock -- avoid collisions with flockmates, maintain velocity with them, and stay close to them. All constraints are prioritized, the most important being the avoidance of obstacles, the other parameters having declining importance. For example, a boid would prefer to change velocity rather than crash into an obstacle.

Craig's program frees the animator from tediously specifying movement for each object and makes it possible to animate a great many objects when the complexity of the script specification would otherwise be extremely difficult. (The film's wide shots of the whole world contain approximately 90 fish and 70 birds.) The boids program essentially automates the work of scripting the complex paths of many objects, thus making certain animation tasks more accessible to the user in the same way that programming in general is becoming easier as lower-level implementation details are covered by layers of abstraction that represent the programmer's actual intent.

The boids themselves are simply S-Geometry objects that, like objects created through use of S-Geometry menus, have their own coordinate systems and acquire their geometric characteristics from the defined class (or flavor) of 3d:object. Boids can be manipulated and rendered just like any other geometric object. However, boids are not

animated individually but as part of a flock. To invoke the flock simulations, Craig adds subsequences that animate the target points toward which the boids fly.

### Netrendering

All during the animating process, shots were being rendered as they were finished, constituting 4200 frames. The problem here was machine time. Assuming an average time of two hours for each frame (two hours was a conservative estimate; many frames were rendered in about 20 minutes), more machine time was required than could be found on the company's currently available machines. Employees at SGD and the Symbolics Cambridge Research Center (SCRC) donated machine time on weekends and evenings. On the most productive weekend, 65 machines at SGD and SCRC were churning out frames. This was still not enough machine time for a film whose most complex scenes contained approximately 225,000 polygons and between 100 and 200 moving objects. Other effects, such as numerous layers of transparency, also required intensive computation.

Fortunately SGD was able to borrow 25 machines at the manufacturing plant in Chatsworth, CA, to be used full time for rendering. (These machines were dubbed the "fish farm.") The 25 machines were net worked together by the NetRender system, a program written by Joseph Goldstone to automate the process of rendering the frames of a script. A script was sent over the network to the "farm" and loaded on a central, controlling machine. (Models for each object were stored at all sites to eliminate transferring objects across the network for each rendering run.) The central machine directed the other machines, designated inkers, to load the script, load any referenced objects or maps, and then "ink" a frame of the script.

The central machine monitored each inker and its frame, farming out frames to idle inkers. If an inker crashed while rendering a frame, the central machine reassigned that frame to the next free inker. Unlike a single-machine render run, a machine crash did not halt the animation. A crash of one machine simply slowed rendering by less than 5%. One morning, a partial power interruption in the San Fernando Valley power grid knocked out most inkers so the farm was running at 20%. but the central machine and a handful of the more determined inkers were unaffected and continued rendering.

### Postproduction

Once the rendering was complete, image data was returned from Cambridge and Chatsworth to SGD over the network. Jim Ryan, the video consultant to SGD, loaded the images into a frame buffer connected to a 1" videotape recorder and dumped the frames to tape. In many cases a frame was recorded on tape within two hours of being rendered. Separate tapes for the foreground scene, starfield, and the mattes from the foreground images were made and then later composited. (See Jim's article on keying.)

### Audio

The music was extremely important in setting the tone for the film. However, the music was of secondary importance to the animators who were concerned primarily with visual effects. Though the animators realized the importance of the background music -- Doc's music very effectively showed how music could convey and even change the mood of a film -- soundtrack concerns were not taken into consideration when the film was designed or animated.

It wasn't until the beginning of July that Jill Frazer was asked to write the music. By that time the animation was complete and her job was to tailor the music to the film. To write the music, Jill listened to previous soundtracks to get an idea of what the animators wanted. She wrote the final music in less than a week. The music she produced not only conveyed the tone the animators were looking for but played a critical part in the overall success of the film.